MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

ETM4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(TE)

12 MARCH 2019
02:30 p.m – 04:30 p.m
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 6 pages with **4** Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) A single mode step-index fiber with a core diameter of 6 μm is designed for operation at a wavelength of 1.35 μm has a core and cladding refractive indices of 1.39 and 1.38 respectively.

(i) Confirm that the fiber will permit single mode transmission.

[6 marks]

(ii) Estimate the range of wavelengths over which this will occur.

[6 marks]

(b) A step index multimode fiber with a numerical aperture of 0.2 supports approximately 1000 modes at an 850-nm wavelength.

(i) What is a diameter of its core?

[5 marks]

(ii) How many modes does the fiber support at 1320 nm?

[2 marks]

(iii) How many modes does the fiber support at 1550 nm?

[2 marks]

(iv) What percent of optical power flows in the cladding for section (ii) and section (iii)?

[4 marks]

Continued...

Question 2

(a) Consider a graded index multimode fiber that has a core radius a=31μm, a profile parameter α=2.15, a core refractive index n_1=1.3, and an index difference Δ=0.02. The fiber pigtail is spliced to a main transmission fiber, which has a core radius 26μm graded index fiber with a numerical aperture of 0.19 and a profile parameter of 1.8. When the fiber axes are aligned without either a gap, radial or angular misalignment, calculate the insertion loss at the splice.

[10 marks]

(b) A multimode has a numerical aperture of 0.32 and a core axis refractive index of 1.33 using return to zero code. The multimode optimum near parabolic profile graded index fiber has a material dispersion parameter of 25 psnm^{-1} km^{-1} when used with a good LED source of rms spectral width 20 nm. The fiber.

(ii) Determine the total rms pulse broadening per km within the fiber assuming waveguide dispersion to be negligible.

[12 marks]

(iii) Estimate the bandwidth-length product for the fiber.

[3 marks]

Continued...

Question 3

(a) A double heterojunction LED is driven by a current of 30mW to generate an internal power of 14mW. The light then emitted from the device and is coupled into a core of step index fiber with a velocity of 2.01×10^8 m/s and critical angle at the core cladding interface 80°. Considering the fiber diameter is bigger than the diameter of the LED.

(i) Determine the peak emission wavelength from double heterojunction LED when the radiative and nonradiative recombination lifetimes of the minority carriers in the active region are equal.

[5 marks]

(ii) Determine the coupling efficiency and the loss in dB when the LED device is close to the fiber.

[10 marks]

(b) Gallium arsenide (GaAs) injection laser with refractive index 3.1 is emitting a 1203 longitudinal modes separated by 280GHz. Hence, the internal quantum efficiency of the laser is 70%. Assume that 322 photons per second generated by this laser source, and only 90% of the generated photons per second are incident on a PIN photodiode.

(i) Calculate the number of injected electrons per second for the laser source.

[2 marks]

(ii) Calculate the quantum efficiency of the PIN photodiode, in case the number of electrons generated by this PIN photodiode is 280.

[2 marks]

(iii) Calculate the responsivity of the PIN photodiode.

[6 marks]

Continued...

Question 4

(a) Consider the design of a typical digital fiber-optic link which has to transmit at a data rate of 20Mbits/s with a BER of 10^{-9} using the NRZ code. The transmitter uses a GaAlAs LED emitting at 850nm, which can couple on an average 100mw (–10dBm) of optical power into a fiber of core size 50mm. The fiber cable consists of a graded-index fiber with the manufacture's specification as follows: Attenuation (α= 2.5dB/km), intramodal dispersion, t_{mat} = 3ns/km, and intermodal dispersion, t_{modal} = 1ns/km. A silicon *p-i-n* photodiode has been chosen, for detecting 850nm optical signals, for the front end of the receiver. The detector has a sensitivity of – 42dBm in order to give the desired BER. The source along with its drive circuit has a rise time of 12ns and the receiver has a rise time of 11ns. The cable requires splicing every 1km, with a loss of 0.5dB/splice. Two connectors, one at the transmitter end and the other at the receiver end, are also required. The loss at each connector is 1dB. It is predicted that a safety margin of 6dB will be required.

(i) Estimate the maximum possible link length without repeaters.

[9 marks]

(ii) Estimate the total rise time of the system for assessing the feasibility of the desired system.

[9 marks]

(b) A 50km optical fiber with loss of 0.2dB/km and has five splices with 0.05dB losses per splice and two connectors with 0.2 dB per connector; used to transmit a data. The receiver sensitivity is 12μW. Express the minimum transmitter power in both mW and dBm.

[7 marks]

End of Page

Appendix I

Physical constants:

vacuum permittivity

$$\varepsilon_0 = \frac{10^{-9}}{36\pi} = 8.85418 \times 10^{-12}\ F/m$$

Vacuum permeability

$$\mu_0 = 4\pi \times 10^{-7} = 1.25663 \times 10^{-6}\ H/m$$

Boltzmann constant

$$k_B = 1.38066 \times 10^{-23}\ J/K$$

vacuum intrinsic (wave) impedance

$$\eta_0 = 120\pi[\Omega]$$

elementary charge

$$q = 1.60218 \times 10^{-19}\ C$$

$$1eV = 1.60218 \times 10^{-19}\ J$$

Plank's constant

$$h = 6.62617 \times 10^{-34}\ J - s$$

Speed of Light

$$c = 2.998 \times 10^{8}\ m/s$$